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PATENT & TRADEMARK OFFICE

Attorney's Docket No.: 3771P001D *Patent*

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re of Application of:

Daniel E. Grupp

Application No.: 09/612,607

Filed: July 7, 2000

Art unit: 2814
Examiner: Wille, Douglas A.

For: Electrostatically Operated Tunneling Transistor

Confirmation No.: 9241

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APPEAL BRIEF
IN SUPPORT OF APPELLANTS' APPEAL
TO THE BOARD OF PATENT APPEALS AND INTERFERENCES

Sir:

This Brief is submitted in support of this appeal from a final decision of the Examiner, mailed March 22, 2005. Consideration of this appeal by the Board of Patent Appeals and Interferences for allowance of the above-captioned patent application is respectfully requested.

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I. REAL PARTY IN INTEREST

The real party in interest is Acorn Technologies, Inc., a corporation of Delaware having a place of business at 881 Alma Real Drive, Suite 305, Pacific Palisades, CA 90272.

II. RELATED APPEALS AND INTERFERENCES

This application was previously the subject of Appeal No. 2002-0243 before APJs Thomas, Barrett and Owens. A decision on that appeal was mailed May 21, 2004, and a copy of that decision is attached hereto as Appendix B.

III. STATUS OF CLAIMS

Claims 23 – 25 are currently pending, have been finally rejected and are the subject of this appeal.

IV. STATUS OF AMENDMENTS

There are no currently pending amendments.

V. SUMMARY OF CLAIMED SUBJECT MATTER

Claims 23, the only independent claim on appeal, reads as follows:[1]

> A method, comprising forming a conduction path between a pair of tunnel junctions (34, 36) each having a resistance less than or equal to approximately a quantum resistance by shifting energy states (58) of an island (26) formed of a material having a non-uniform density of such energy states characterized by separated conduction and valence bands (54, 56) that behave as continuous energy bands, the island being disposed between the tunnel junctions.

Claim 23 thus concerns an electronic device in which a conduction path from a source to a drain (or vice versa) passes through a pair of tunnel junctions. The tunnel junctions are separated by an island of, for example, semiconductor material (or another material having a non-uniform density of energy states) and each has a resistance less than or equal to approximately a quantum resistance. A conduction path is formed by shifting energy states of the island. In this context, the phrase "non-uniform density of energy states" means at least one region that contains available energy states adjacent to at least one region that does not contain any available energy states. Specification at page 6, lines 1-17; page 9, line 17 – page 10, line 3. The energy states are characterized by separated conduction and valence bands that behave as continuous energy bands.

One method of operating an n-type transistor-like device configured in accordance with the present invention is explained at page 15, lines 6 – 17 of the Specification, with reference to Figure 6. In summary, if a small bias voltage is applied between a source and a drain of the device and no gate voltage is applied (i.e., the gate and drain are held at the same voltage) current will not tunnel between the source and the drain because the bottom

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[1] Reference numbers as used in the drawings have been inserted in accordance with 37 C.F.R. § 41.37(c)(1)(v). The use of such reference numbers should in no way be read as limiting the claim to the illustrated embodiment.

edge of the island's conduction band is higher in energy than the source Fermi energy. However, when a positive voltage is applied to the gate with respect to the drain, the conduction band is lowered in energy so that it aligns with the source and drain Fermi energies. Therefore, when a small negative voltage is applied to the source with respect to the drain, electrons can tunnel from the source, through one of the tunnel barriers to the island, and through the second tunnel barrier to the drain. Alternatively, a negative voltage applied to the drain will cause electrons to tunnel in the opposite direction. Therefore, a sufficiently positive bias voltage applied to the gate (with respect to the drain) allows the device to conduct current in both directions.

V. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

Claims 23 - 25 were rejected under 35 U.S.C. 102(e) as being anticipated by Ellenbogen, U.S. Patent 6,339,227 ("Ellenbogen"),[2] which is asserted to show "a three terminal device with a pair of tunnel junctions and a molecule which is effectively an island and having energy bands of molecular orbitals.

VIII. ARGUMENT

The present claims are patentable over Ellenbogen, which fails to teach or suggest a method in which a conduction path is formed in a device with an island having a valence and a conduction band that behave as continuous (and NOT discrete) energy bands.

To anticipate a claim, a reference must teach every element of that claim. Stated differently, "A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference." Verdegaal Bros. v. Union Oil Co. of California, 814 F.2d 628, 631, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987). Here, the discrete nature of the energy states of the "island" molecule described by Ellenbogen is quite different from what is claimed in the present application. Claim 23 recites an island having a valence and a conduction band, which behave as continuous energy bands. This is a fundamental distinction between the device described by Ellenbogen and the presently claimed invention and, hence, the present claims are patentable over this reference.

Before considering the distinctions between the claimed invention and the device described by Ellenbogen, some background is helpful. In seeking to address problems that have been encountered when trying to construct MOSFET devices with channel lengths less than 0.1 microns, researchers have been investigating transistor devices based on the quantum behavior of electrons. A number of very small-scale devices that exploit electron tunneling are known in the art; among these are resonant tunneling transistors (RTTs) and single electron transistors (SETs).

The present invention differs from conventional SETs in that it employs low resistance tunnel junctions. More specifically, the present invention provides a device having a pair of tunnel junctions, each with a resistance less than or equal to approximately the quantum resistance ($R_q \approx h / 2e^2$), and being separated by an island

formed of a material having a non-uniform density of energy states. Furthermore, the present invention differs from RTTs and similar devices, which rely on quantum wells to set the energy scale of the device for its operation. See, e.g., Specification at page 9, lines 2 – 11.

Turning now to the rejection of claim 23 as being anticipated by Ellenbogen, this rejection reflects a basic and fundamental misunderstanding of the nature of the present invention. The device described by Ellenbogen is best classified as a resonant tunneling transistor structure. It operates by using a gate-like terminal to bring the energy levels of a central or channel region disposed between two tunnel junctions into resonance (i.e., the same energy level) with the Fermi level of the contacts to the tunnel junctions. More simply put, the energy level of the channel region is made to line up with the energy level of the leads contacting the tunnel junctions, thereby permitting conduction.

Importantly, the channel region of the Ellenbogen device consists of a molecule, the energy levels of which are discrete in nature. The most relevant levels in this molecule for conduction are the HOMO (highest occupied molecular orbit) and the LUMO (lowest occupied molecular orbit), which are separated by an energy gap. Generally, the LUMO must be lined up with the Fermi level of the leads in order for conduction to occur. However, the LUMO is one single energy state, such that <u>there are no energy states in the molecule just above or below the LUMO</u>.

This discrete nature of the energy states of the "island" molecule described by Ellenbogen is quite different from what is recited in claim 23. Claim 23 specifically identifies an island having a valence and a conduction band, which behave as continuous (and NOT discrete) energy bands. Stated differently, the molecular island described by Ellenbogen is not "an island formed of a material having a non-uniform density of energy states characterized by separated conduction and valence bands that behave as continuous energy bands" as recited in claim 23 of the present application. This is a fundamental distinction between the device described by Ellenbogen and the presently claimed invention and, consequently, the Ellenbogen reference cannot anticipate the present claims.

IX. CONCLUSION

For at least the foregoing reasons, Appellant respectfully requests reversal of the Examiner's rejections as set forth in the Final Office Action and requests that the Board direct allowance of claims 23 - 25. If there are any additional fees associated with this communication, please charge our deposit account 02-2666.

Respectfully submitted,
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[2] Final Office Action of March 22, 2005, p. 2.

APPENDIX A: Claims on Appeal

(37 C.F.R. § 41.37(c)(1)(viii))

The claims on appeal read as follows:

23. (Previously Amended) A method, comprising forming a conduction path between a pair of tunnel junctions each having a resistance less than or equal to approximately a quantum resistance by shifting energy states of an island formed of a material having a non-uniform density of such energy states characterized by separated conduction and valence bands that behave as continuous energy bands, the island being disposed between the tunnel junctions.

24. (Original) The method of claim 23 wherein the energy states of the island are shifted by application or removal of a voltage through an electrode capacitively coupled to the island.

25. (Original) The method of claim 24 further comprising passing a current through the conduction path via electrodes coupled to the tunnel junctions.

APPENDIX B: Related Proceedings

(37 C.F.R. § 41.37(c)(1)(x))

A copy of the Decision on Appeal for Appeal No. 2002-0243 is attached.

The opinion in support of the decision being entered today was <u>not</u> written for publication and is <u>not</u> binding precedent of the Board

Paper No. 14

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

Ex parte DANIEL E. GRUPP

Appeal No. 2002-0243
Application No. 09/612,607

MAILED
MAY 21 2004
U.S. PATENT AND TRADEMARK OFFICE
BOARD OF PATENT APPEALS
AND INTERFERENCES

ON BRIEF

Before THOMAS, BARRETT and OWENS, *Administrative Patent Judge.*

OWENS, *Administrative Patent Judge.*

DECISION ON APPEAL

This appeal is from the final rejection of claims 23-25, which are all of the claims pending in the application.

THE INVENTION

The appellant claims a method for forming a conduction path between a pair of tunnel junctions. Claim 23 is illustrative:

23. A method, comprising forming a conduction path between

a pair of tunnel junctions each having a resistance less than or equal to approximately a quantum resistance[1] by shifting energy states of an island formed of a material having a non-uniform density of energy states,[2] the island being disposed between the tunnel junctions.

THE REFERENCE

Serge Luryi and Federico Capasso (Luryi), "Resonant tunneling of two-dimensional electrons through a quantum wire: A negative transconductance device", 47 *Appl. Phys. Lett.* 1347-49 (1985).

THE REJECTION

Claims 23-25 stand rejected under 35 U.S.C. § 102(b) as being unpatentable over Luryi.[3]

OPINION

We affirm the aforementioned rejection.

The appellant states that the claims stand or fall together (brief, page 4). We therefore limit our discussion to the sole independent claim, i.e., claim 23. *See In re Ochiai*, 71 F.3d

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[1] The appellant states that a quantum resistance is 26 KOhms (specification, page 4, lines 22-23).

[2] The appellant states that a material having a nonuniform density of energy states is one having "at least one region that contains available energy states adjacent to at least one region that does not contain any available energy states" (specification, page 6, lines 6-7).

[3] A rejection of claims 23-25 under 35 U.S.C. § 112, second paragraph, is withdrawn in the examiner's answer (page 3).

1565, 1566 n.2, 37 USPQ2d 1127, 1129 n.2 (Fed. Cir. 1995); 37 CFR § 1.192(c)(7)(1997).

Luryi discloses a method comprising forming a resonant tunneling structure (abstract). The structure includes a pair of AlGaAs barrier layers which the examiner relies upon as being the appellant's tunnel junctions (answer, page 3). It is undisputed that each of the AlGaAs barrier layers has a resistance less than or equal to approximately a quantum resistance.[4] Between the AlGaAs barrier layers is a GaAs layer (figure 1) which the examiner relies upon as being the appellant's island (answer, page 3). Because, as pointed out by the appellant (specification, page 11, lines 11-12), the island can be any semiconductor material, Luryi's GaAs semiconductor material necessarily has the nonuniform density of energy states required of the appellant's island material. Luryi can control resonant tunneling by use of a gate voltage that shifts those energy states (page 1349).

The appellant argues that "[t]he present claims make it

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[4] The appellant states that the appellant's tunnel junctions which have a resistance less than or equal to approximately a quantum resistance can be made of an insulating material, such as silicon dioxide or aluminum oxide, or can be made of an oxide of the material of which the island is made (specification, page 7, lines 9-10; page 10, lines 17-19).

clear that a non-uniform density of states is a specific property of the island material, not one arising from geometrical structures in the device, as in a quantum well" (brief, page 5). Because, as indicated by the appellant's specification (page 6, lines 5-6; page 11, lines 11-12), a nonuniform density of energy states is a property of semiconductors, Luryi's GaAs semiconductor necessarily has that property.

The appellant argues that "the present invention relates to a device having a non-uniform density of energy states. That is, a device in which separated conduction and valiance [sic, valence] bands behave as continuous, and not quantum, energy bands" (brief, page 5). The appellant's specification states that a material having a nonuniform density of energy states is a material that has "at least one region that contains available energy states adjacent to at least one region that does not contain any available energy states" (page 6, lines 6-7). The appellant's specification also states that the spacing between the energy levels of the island material depends upon the material and the size of the island, and that it is preferred that the energy levels are spaced by a maximum of 100meV so that the valence and conduction bands behave as approximately continuous bands, thereby causing electrons at room temperature

to have enough thermal energy to travel between the energy levels (page 13, lines 17-26). Thus, the specification indicates, contrary to the appellant's argument, that the conduction and valence bands behaving as continuous energy bands is not necessarily a characteristic of the material having a nonuniform density of energy states required by claim 23 but, rather, is a feature of a preferred island design not required by claim 23.

The appellant argues that "[t]he band structure of the [appellant's] device may look similar to that of Luryi's quantum well, but the origin of this structure is entirely different" (brief, page 5). By "origin of this structure" the appellant apparently is referring to features that are not required by claim 23. Any such non-claimed features are not useful for distinguishing over Luryi the method claimed in that claim. *See In re Self*, 671 F.2d 1344, 1348, 213 USPQ 1, 5 (CCPA 1982).

We therefore find that the appellant's claimed method is anticipated by Luryi.

DECISION

The rejection of claims 23-25 under 35 U.S.C. § 102(b) over Luryi is affirmed.

AFFIRMED

JAMES D. THOMAS)
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)
LEE E. BARRETT)
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